

Thermal neutron capture cross sections of tellurium isotopes^a

I. Tomandl¹, J. Honzátko¹, T. von Egidy², H.-F. Wirth², T. Belgya³, M. Lakatos³, L. Szentmiklósi³, Zs. Révay³,
G. L. Molnár³, R.B. Firestone⁴, and V. Bondarenko⁵

¹ Nuclear Physics Institute, 250 68 Rež, Czech Republic

² Physik Department, Technische Universität München, D-85748 Garching, Germany

³ Institute of Isotope and Surface Chemistry, Chemical Research Centre of Hungarian Academy of Sciences, H-1525 Budapest, Hungary

⁴ Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

⁵ Institute of Solid State Physics, University of Latvia, Riga LV-1063, Latvia

This publication reports new thermal neutron capture cross section values leading to the ground or isomeric states for all stable Te isotopes except ¹²⁰Te and ¹²³Te. In addition, several elemental partial γ -ray cross sections are reported for the stable Te isotopes except for ¹²⁰Te. In the present work we used a combination of γ -ray emission probabilities per capture, or absolute γ -ray intensities $I\gamma$ determined in (n, γ) measurements with highly enriched targets, and elemental partial γ -ray production cross sections σ_{γ}^{elem} of a natural Te target for the determination of the total neutron capture cross sections of tellurium isotopes. The experiments with the enriched targets were performed at the thermal neutron facility in Rež. The ¹²⁵Te(n, γ) experiments were performed at PSI, Villigen, Switzerland. Absolute γ -ray intensities per neutron capture were determined using two methods. In the cases of ¹²⁸Te and ¹³⁰Te, the known γ intensities of lines following the β decay of the produced isotopes were applied for the calibration. In other cases we made the assumption that the observed percentages of the sum of the ground- and isomeric-state populations in our recent experiments amount to (90 \pm 10)% for each neutron capture in the cases of ¹²⁴Te and ¹²⁶Te, (80 \pm 15)% for ¹²²Te and (80 \pm 12)% for ¹²⁵Te. The assumptions of the observed percentages are based on the estimation of the most probable value of the lost intensity ending at the ground or isomeric state. To obtain these values of the lost intensities we combined the detection limits of the individual experiments, the systematics of tellurium isotopes, the population-depopulation balances of lowlying levels, and the two-step cascade spectra, from which the percentage of the two-step cascade intensity of unresolved weak transitions can be extracted. These procedures can be checked by means of the heavy tellurium isotopes, ¹²⁶Te, ¹²⁸Te, and ¹³⁰Te, which can be normalized via a β decay. A good agreement for all three isotopes between these two normalizations validates our procedure of normalization of the light tellurium isotopes. Partial γ -ray production cross sections for the strongest lines of each major contributing isotope of almost all elements have been determined at the old Budapest PGAA facility. The relevant value for Te was 2.4(2) b for the 603 keV γ -ray from the ¹²³Te(n, γ) isotope. However, its large uncertainty (due to low counting statistics) was not good enough for our purpose. Therefore, it was necessary to re-measure this number with substantially higher precision and provide partial cross section values for at least one γ line from each of the other Te isotopes as well. The new σ_{γ}^{elem} values for Te were determined by using the internal standardization method. The measurements were performed at the new cold neutron PGAA facility of the Budapest Re-

search Reactor. The neutron flux on target amounted to 5 \times 10⁷ cm⁻²s⁻¹, 25 times higher than that of the old guided thermal beam. We accumulated an (n, γ) spectrum of 0.312 g natural tellurium-oxide powder to determine the relative intensities of gamma rays in the natural Te. The sample was packed in a thin Teflon bag and had dimensions of 17 \times 17 \times 1 mm³. It was placed in the PGAA sample holder and irradiated for about 230,000 s. In separate experiments with 0.194 g natural tellurium oxide dissolved in 2.151 g 20 mol % hydrochloride acid. We redetermined the elemental partial γ -ray cross section for the 603 keV transition from the ¹²³Te(n, γ) reaction. The solution was kept in a thin-walled cylindrical Teflon container. Two (n, γ) spectra were accumulated for about 74,600 s and 1000 s, respectively. From the shorter experiment we crosschecked the hydrogen concentration of the solution relative to its chlorine content. We found that it corresponded to the nominal concentration of the 20 mol % hydrochloride acid. From the longer experiment we determined the σ_{γ}^{elem} for the 603 keV ¹²³Te(n, γ) γ ray using several comparator γ rays from the ³⁵Cl(n, γ) reaction and the only γ ray from the ¹H(n, γ) reaction. The unweighed average and its external standard uncertainty is 2.908 \pm 0.049 b. Using the partial cross section of the 603 keV and the relative peak intensities obtained from the spectrum of the natural tellurium oxide, we have determined the elemental partial production cross sections for some of the most intense γ rays of the tellurium isotopes. We stress that these values are independent from the energy distribution of the neutron beam due to the 1/ ν dependence. All Westcott g factors are practically unity. The only exception is ¹²³Te, which has the value of 1.013 at 300 K. Since this factor is unity within the overall experimental uncertainty, it has been neglected. Combining Rež and Budapest results, one can calculate the thermal neutron capture cross sections for the tellurium isotopes from the absolute γ intensities $I\gamma$ (i.e., emission probabilities per capture) and the new elemental partial γ -ray cross sections σ_{γ}^{elem} measured at Budapest using the equation $\sigma_{n\gamma} = \sigma_{\gamma}^{elem} / \theta \times I\gamma$, where θ is the natural abundance of the given isotope. In order to reduce the statistical uncertainties the total capture cross sections $\sigma_{n\gamma}$ were obtained as averaged values from at least three different lines for each isotope.

^a Phys. Rev. C68, 067602 (2003).